A. O. Smith Training Department

Technical Bulletin TB-A023-06

Air Pressure Switches

This bulletin has been prepared to explain and illustrate the construction, operation, and testing procedures for various types of air pressure switches used on residential and commercial tank type water heaters.

Air pressure switches are used on all “fan assisted” gas fired water heaters in our product line. Air pressure switches are used to verify that operational conditions are being met; IE: the blower is running or the vent/combustion air piping length is not excessive or obstructed.

Air pressure switches are usually wired together with other switches into a “series” circuit (see page 8). The ignition control constantly monitors the “state” of the air pressure switch “circuit” - whether it is open or closed. There will always be at least one air pressure switch that has normally open contacts (see pages 7 & 8). As the blower starts and comes up to speed the normally open contacts of this switch should “activate” (contacts will close) in response to the pressure it senses – as long as there are no adverse operating conditions.

Normal Operating Sequence - Pressure Switch Circuit

(Power-Vent, Power Direct-Vent, Cyclone, Master-Fit BTN/BTI models)

1. At the beginning of a heating cycle the ignition control will verify the air pressure switch circuit is open **before** the control energizes the blower motor.

2. After successfully completing the above open circuit verification step, the ignition control will energize the blower, the control will then check the air pressure switch circuit a second time **after** the blower is energized. This time the pressure switch circuit must be verified closed. The ignitor would not be energized unless this circuit closes after the blower is energized.

3. The ignition control monitors this circuit **during** the entire heating cycle to ensure it remains closed. If this circuit opens (even for a split second) during the heating cycle; the control will close the gas valve and stop the heating cycle.

By monitoring the air pressure switch circuit an ignition control can perform critical operational checks such as:

1. Verify normally open air pressure switch contacts are not stuck closed or jumpered.
2. Verify the combustion blower or inducer fan is running.
3. Verify the vent/combustion air piping length is not excessive and/or obstructed.

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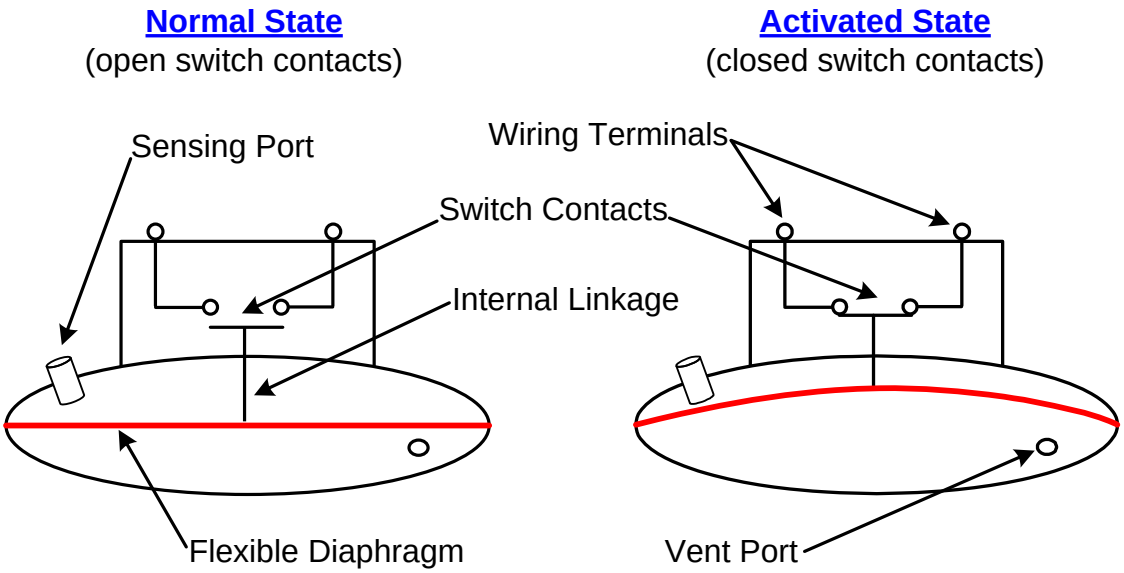
Air Pressure Switch Construction



Air Pressure Switch Operation

Air pressure switches activate in response to pressure sensed through a tube. One end of this tube attaches to the pressure switch sensing port, the other end attaches to a pressure sensing port somewhere on the water heater, IE: the vent system, blower assembly.

A flexible diaphragm divides the body of the switch into two air chambers. The sensing port is attached to one air chamber. The other air chamber is vented to the atmosphere which allows the diaphragm to move. Internal linkage attaches the switch contacts to the diaphragm; with sufficient pressure applied, diaphragm movement will activate the switch contacts.

Contact States:

The “state” of the contacts refers to whether or not the switch contacts are open or closed. Closed contacts will allow electricity to flow through the switch because there is a continuous “conductive” path through the switch contacts. Open contacts will not allow electricity to flow, there is no “continuity” through the switch contacts. The state of the contacts, open or closed, can be verified/confirmed with an ohm meter. An ohm meter is required to perform conclusive diagnostic tests on air pressure switches.

With air pressure switches the term “**normal state**” refers to whether or not the switch contacts are open or closed when there is no pressure applied to the switch. Switches can be **normally open** or **normally closed**, abbreviated NO or NC in technical literature.

The “**activated state**” of a switch is the opposite of the normal state. A normally open switch in it’s activated state is closed. A normally closed switch in it’s activated state is open.

Air pressure switches are described by their normal state and by their “contact action” which is covered on the following page.

Air Pressure Switch Operation (cont)

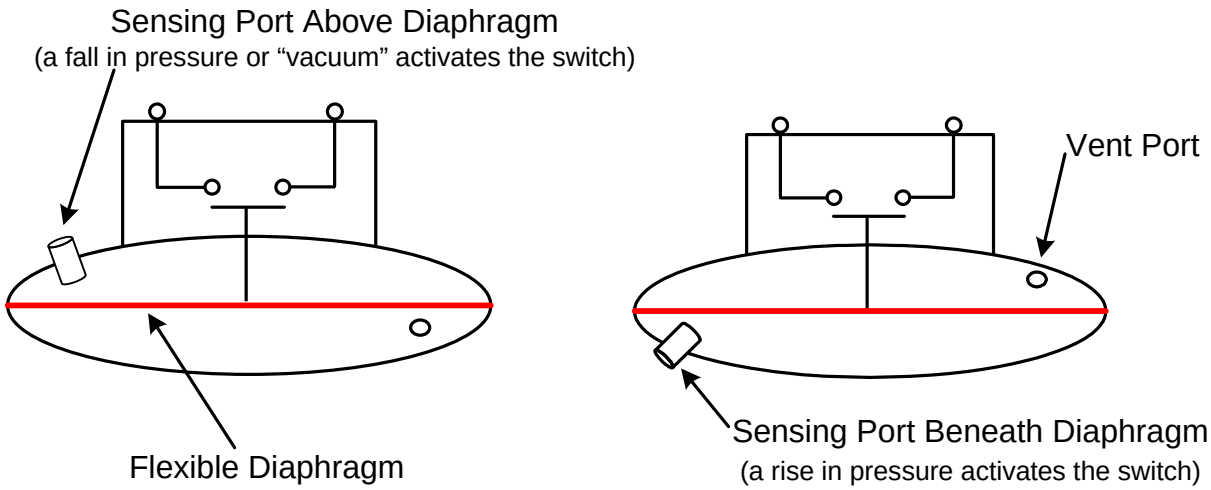
Contact Actions:

The “action” of the contacts refers to what causes the switch to activate, to change from it’s “normal state” to its “activated state” (see page 2). On an air pressure switch this can be either a rise or fall in pressure. As the illustrations below indicate, locating the sensing port above or below the flexible diaphragm facilitates these operational differences. The contact action is further described to convey whether the contacts will open or close when the pressure sensed is sufficient to activate the switch contacts, IE: “close on a fall in pressure.”

Pressure Switch Descriptions:

Air pressure switches are described and referred to by their Contact State and Contact Action. IE: the switch on the left side in the illustration below is a “normally open, close on a fall” pressure switch. See page 7 for more information about other types of switches.

Normally Open, Close on a Fall **Normally Open, Close on a Rise**


Sensing Port Above Diaphragm
(a fall in pressure or “vacuum” activates the switch)
Flexible Diaphragm
Vent Port
Sensing Port Beneath Diaphragm
(a rise in pressure activates the switch)

Service Note:
Because one of the two air chambers is vented to the atmosphere, the ambient (in the surrounding area) air pressure is critical. Ambient air pressure can push or pull on the diaphragm through the vent port. If the ambient air pressure is extremely high (positive) or low (negative) it may cause erratic pressure switch operation.

Direct vent installations will not eliminate this potential problem.

Tools Required for Testing

A volt/ohm multi-meter - Fieldpiece HS36 DMM (digital multi-meter) or equivalent.

A digital manometer is also required to measure pressure and perform conclusive diagnostic tests. Specifications: range; -15.0" W.C. to +15.0" W.C. resolution; 0.01" W.C. Brands/models recommended that meet these specifications include: UEI model EM-200 and Extech model 406850 dual pressure reading digital manometers.

Air Pressure Switch Testing

Continuity Test With Ohm Meter
Power-Vent Residential Model

Continuity Test With Ohm Meter
BTH 120 - 250 Blocked Exhaust Switch

Testing the performance of air pressure switches involves three procedures.

First Procedure is a normal state test to determine if the switch contacts are open or closed in the normal state (see page 2) without pressure applied. Power is turned off for this test. The wires to the switch are disconnected. A continuity test is then performed (ohm meter) between the wiring terminals on the switch. If the switch is a “normally open” switch (see page 2) the continuity test should indicate no continuity - open. If the result of this test indicated the contacts were closed, the switch must be replaced. Likewise if a “normally closed” switch’s contacts tested open in its normal state it would also have to be replaced. Note: gaining access to the switch and it’s wiring terminals may involve removing the switch, opening a control box etc.

THE SECOND AND THIRD PROCEDURES ARE PERFORMED WITH THE BLOWER RUNNING.

Second Procedure is an operational test to determine if the switch contacts are open or closed while the blower is running and pressure is applied to the switch. The wires to the switch remain disconnected and a continuity test is performed as in the first procedure above. Ensure the wires ends do not touch/short to ground. Ensure the sensing tube is properly connected at both ends and test for continuity with the blower running at full speed. Note the condition of the switch contacts; whether open or closed.

Normally open air pressure switches must close during operation and normally closed air pressure switches must remain closed throughout the heating cycle on A. O. Smith fan assisted water heaters. This information can usually be found in the sequence of operation section of the owner’s manual and/or service manual for the product. Contact the A. O. Smith technical information center (800 527-1953) for more information.

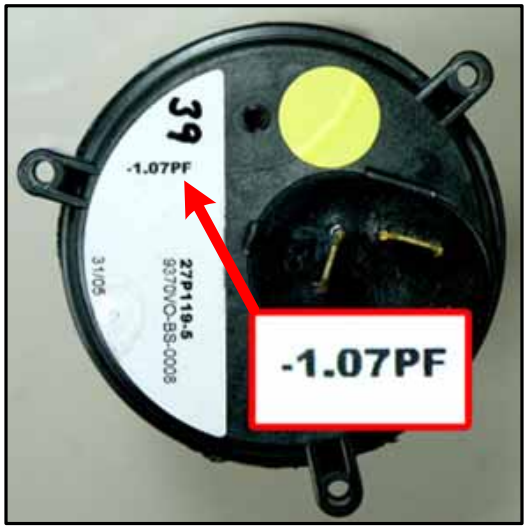
Normally open switches: If the air pressure switch being tested is a normally open switch, it must close it’s contacts (activate) before ignition can occur. If the continuity test indicates a normally open switch’s contacts have closed while the blower is running, the switch is operating correctly. If the continuity test indicates the switch contacts are remaining open while the blower is running the third “pressure test” procedure will have to be performed. This will determine if the switch is defective or if the switch contacts are failing to close because the pressure being sensed has not reached the “activation point” for the switch. This is covered on the next page.

Normally closed switches: If the air pressure switch being tested is a normally closed switch, the switch contacts must remain closed throughout the heating cycle. If the continuity test indicates a normally closed switch’s contacts remain closed while the blower is running, the switch is operating correctly. If the continuity test indicates the switch contacts are opening after the blower starts the third “pressure test” procedure will have to be performed. This will determine if the switch is defective or if the switch contacts are opening because the pressure being sensed has reached or exceeded the “activation point.” This will be covered on the next page.

Air Pressure Switch Testing (cont)

Blocked Vent Switch - Pressure Test
Vertex Residential Power Vent Model

The pressure activation point for the air pressure switch below is - 1.07" W. C. (inches water column) This is a negative pressure value – in a vacuum.



Blocked Vent Air Pressure Switch
Residential Power Vent Model

Third Procedure is a pressure test and requires a digital manometer capable of reading positive and negative pressures. A good range of operation would be +15.00 “W.C. to -15.00 “W.C. (inches water column) with a resolution of 0.01 “W.C. Recommend the UEI model EM-200 or Extech model 406850 dual pressure digital manometers, not shown here.

To determine if an air pressure switch is operating properly you must know the “pressure activation” point for the switch and whether it activates on a rise or a fall in pressure. The activation point is a given pressure value and may be a positive or negative (in a vacuum) pressure. This information is often provided on the switch label (see image above). Whether the switch activates on a rise or fall in pressure is the type of switch action, this information is available here (page 7) for most current residential and commercial fan assisted water heaters. Contact the technical information center 800 527-1953 when the activation point and/or switch action are not known. Have the complete water heater Model, Serial, and Series number on hand before calling.

Taking Air Pressure Readings: Disconnect the pressure sensing tube from the sensing port on the switch, leave the other end connected. Examine the sensing tube connection on the water heater, check for wear, leaks, kinks, or any kind of debris or condensate in the sensing tube, repair/replace as necessary. Connect a digital manometer to the pressure switch end of the sensing tube as shown above. Turn the power on and ensure a call for heat is active. When the blower starts and comes up to full speed, record the pressure reading.

Normally Open Switches: Normally open air pressure switches must close their contacts after the blower is energized, the pressure reading taken must reach or exceed the activation point (pressure value) for the pressure switch being tested or the contacts will not close.

Pressure reading taken DOES NOT reach activation pressure:

DO NOT replace the air pressure switch if the contacts do not close during second procedure. The switch is not defective. IE: Residential power vent product - the pressure switch on these products is a “normally open - closes on a fall in pressure” switch (see page 7). If the activation point for the switch is - 1.07” W.C. and the actual pressure reading taken was - 0.85" W.C., the actual pressure has not reached the activation point. The switch contacts will not close until the pressure reaches or exceeds - 1.07" W. C..

Blocked Exhaust Switch Pressure Test
Cyclone - BTH 300/400 Models

Blocked Exhaust Switch Pressure Test
Cyclone - BTH 120 - 250 Models

Air Pressure Switch Testing

Third Procedure - Normally Open Switches (cont):

Pressure reading taken DOES NOT reach the activation pressure (cont):

Ensure the sensing tube is connected securely and not blocked with any debris or condensate. Ensure the tube is not kinked or leaking. On residential power vent models check vent piping for excessive length or number of elbows, check for obstructions in the vent pipe. On Cyclone BTH models ensure the minimum vent pipe length requirement (7' BTH 120 - 250, 15' BTH 300/400) has been met. Ensure the blower wheel is clean on all models. This can become dirty over time or during construction on new water heaters and cause operational problems.

Pressure reading taken DOES reach the activation pressure:

If the test results for the second procedure indicated the normally open switch contacts did not close and the pressure reading taken during the third procedure indicated the pressure sensed by the switch did reach or exceed the activation point (pressure value) for the switch, the switch is defective and should be replaced.

Normally Closed Switches: Current design residential power-vent/power direct-vent and commercial BTI/ BTN models are not equipped with normally closed air pressure switches. Cyclone BTH 120 – 400 models are equipped with two normally closed air pressure switches; a blocked inlet and blocked exhaust switch (see pages 7 & 8). Normally closed switches should remain closed at all times unless there is an operational problem.

Pressure reading taken DOES NOT reach the activation pressure:

If the test results for the second procedure indicated a normally closed switches contacts were opening during blower operation AND the pressure reading taken DOES NOT reach or exceed the activation point (pressure value) for the switch, the switch is defective and should be replaced.

Pressure reading taken DOES reach the activation pressure:

If the test results for the second procedure indicated a normally closed switch contacts were opening during blower operation AND the pressure reading taken DOES reach or exceeds the activation point for the switch DO NOT replace the switch, it is not defective. Ensure the intake air or vent piping is not excessive and both are free of obstructions. Always check the owner's manual vent installation section for proper intake air and vent pipe installation requirements.

Air Pressure Switch Types

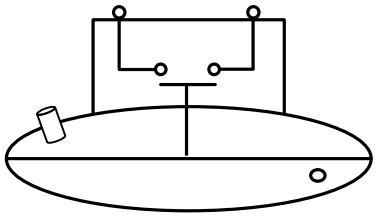
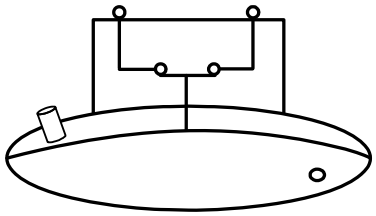
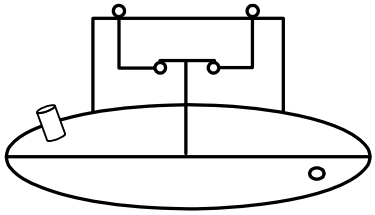
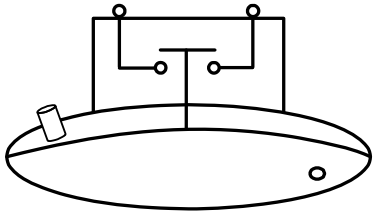
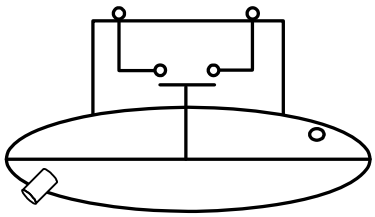
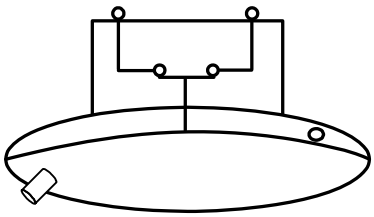
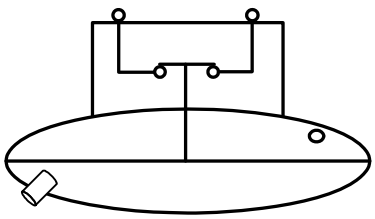
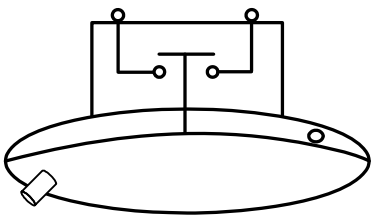
Contact States

Normally Open = NO
Normally Closed = NC

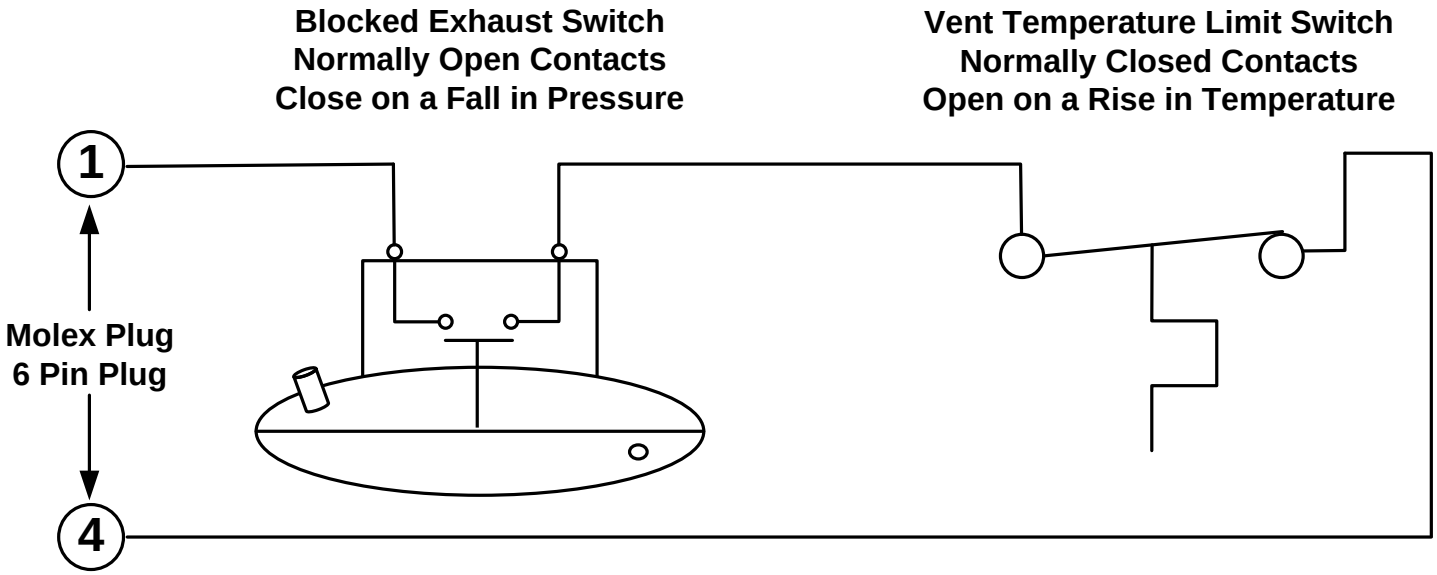
Contact Actions

Close on a rise in pressure
Close on a fall in pressure

Open on a rise in pressure
Open on a fall in pressure

Application	Normal State	Activated State
Blocked Exhaust Air Pressure Switch Power-Vent & Power Direct Vent Residential Models **Blower Prover Air Pressure Switch BTI/BTN 120 – 400 Models**		
	Normally open contacts, close on a fall in pressure.	
Blocked Intake Air Pressure Switch Cyclone BTH 120-400 Models		
	Normally closed contacts, open on a fall in pressure.	
Blower Prover Air Pressure Switch Cyclone BTH 120-400 Models		
	Normally open contacts, close on a rise in pressure.	
Blocked Exhaust Air Pressure Switch Cyclone BTH 120-400 Models		
	Normally closed contacts, open on a rise in pressure.	

Air Pressure Switch Circuit
Residential Power-Vent & Power-Direct-Vent Water Heaters



Air Pressure Switch Circuit
Cyclone Water Heater